CINT Workshop Discussion Session

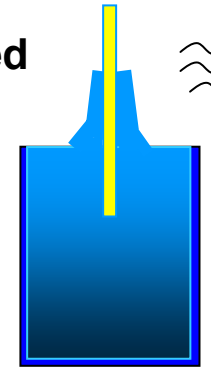
Challenges in nanoscale materials synthesis, integrations & applications

- New nanoscale building blocks (inorganic, organic, bio,…)
- Self assembly, directed assembly, nano-assemblers
- Bio-inspired synthesis, bio-mimetic structures
- Predictable, robust, scalable processing of nanomaterials
- Combining bottom-up and top-down synthesis approaches
- Unique materials properties from nanoscale structure/interactions
- Integration of hard and soft/bio materials, novel composites
- From novel nanomaterials to device integration & applications
- Novel approaches to device design & fabrication
  - Non-traditional lithography
  - Stamping, Imprinting

What are the Grand Challenges we want to Pursue?

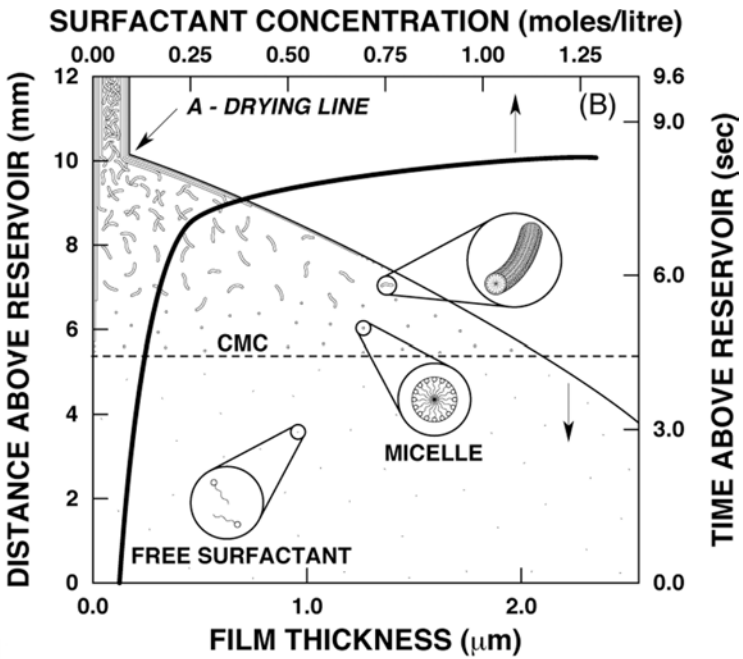
Self assembly is a powerful approach to ordering materials at the nanoscale

Evaporation-induced self assembly is used to fabricate ordered thin films

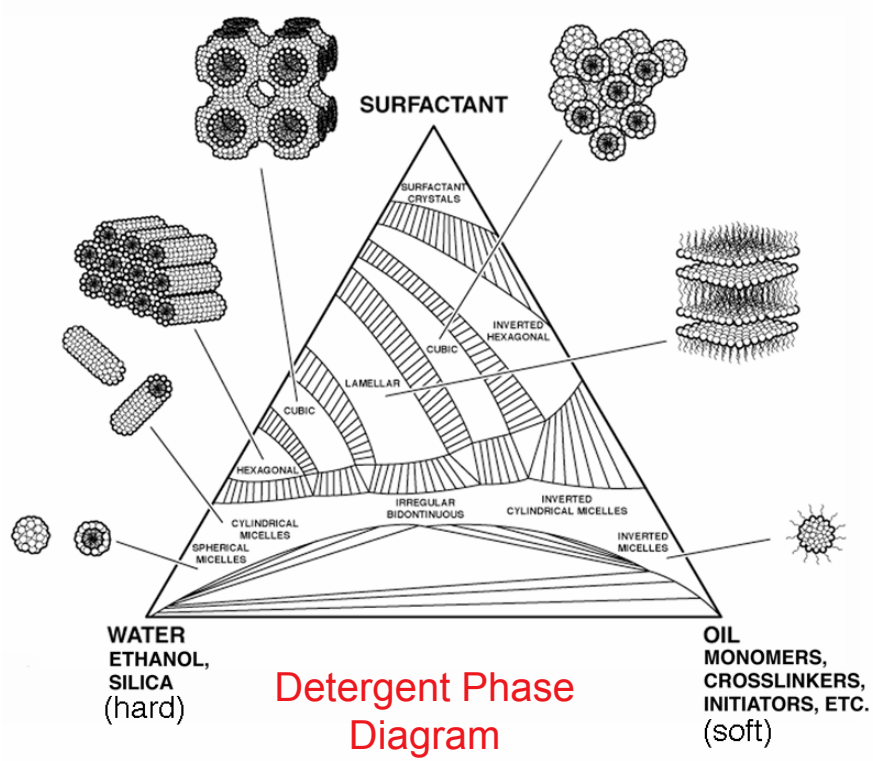


Solvent Evaporation

Dip coating



Surfactants can be used as structure-directing agents & monomers to create polymer nanocomposites



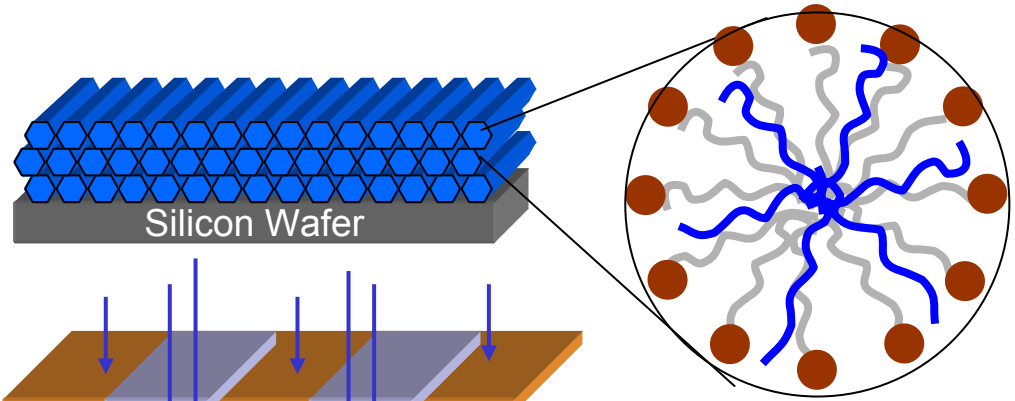
Detergent Phase Diagram

(Scriven, Davis)

Research team: Jeff Brinker et. al.

Self-assembly approaches can be used to integrate unique functionality in films

Self assembly of photosensitive silica/surfactant mesophase containing a photoacid generator



incorporation of the PAG in the micelle

Selective UV exposure through mask

Compartmentalized production of acid

Selective etching of unexposed mesostructure

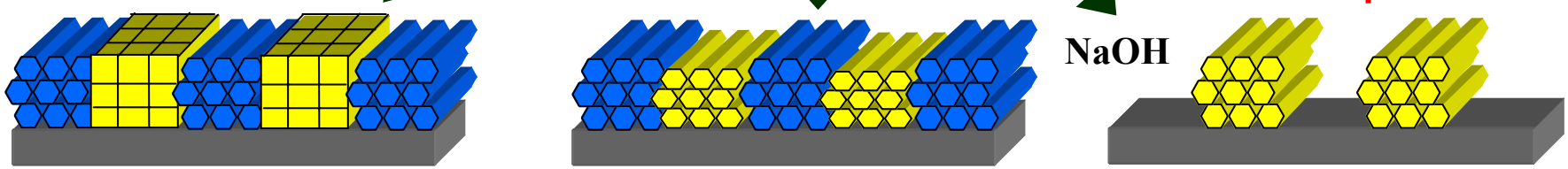
(Doshi et al., Science, 2000)

Heat treatment

T > 125 °C

NaOH

Patterned Thin Film Mesophase



Nanostructural Lithography

with phase transformation

without phase transformation

Research team:
J. Brinker, D. Doshi

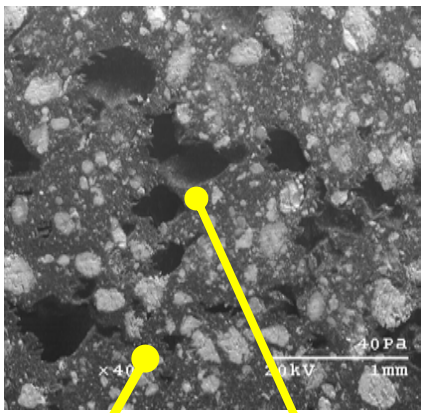
Los Alamos

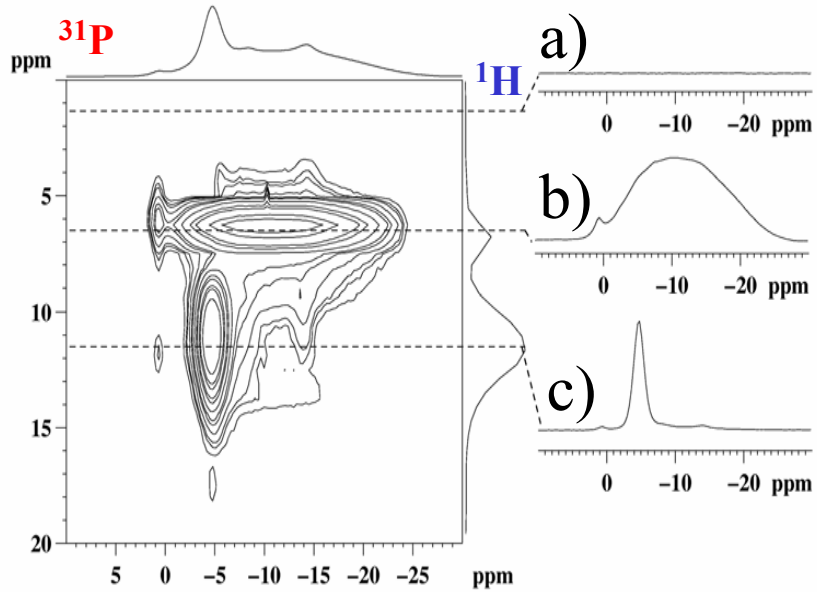
Sandia National Laboratories

Multidimensional Heteronuclear NMR is being used to probe of interfaces in nanohybrids

Using new NMR techniques to selectively observe interfaces in nanohybrid materials

- **Spectroscopic characterizing of nanohybrid interface showed:**
- **The homogeneous mixing of inorganic/organic phases at the nanoscale.**
- **Processing produced chemical alteration of inorganic phase (unexpected!).**



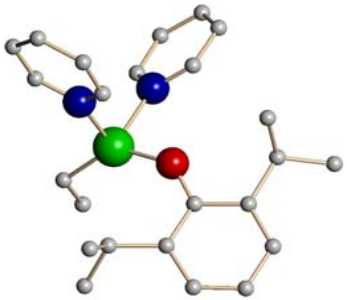


B. C. Tischendorf, D. J. Harris, J. U. Otaigbe, T. M. Alam "Investigation of Structure and Morphology Dynamics in Tin Fluorophosphate Glass-Polyethylene Hybrids Using Solid-State ^{1}H, ^{13}C and ^{31}P MAS NMR", *Chemistry of Materials* 14, 341-347 (2002).

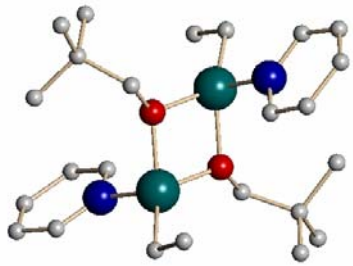
Research team: Todd Alam and Brian Cherry

Precursor structure dramatically effects nanoparticle size, morphology, and phase

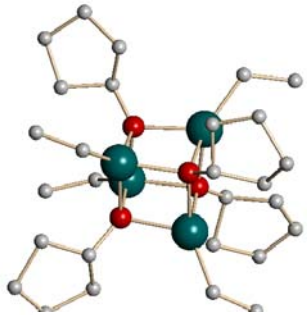
$Zn(Et)_2 + HOR \longrightarrow Zn(Et)(OR)(solv)_x$



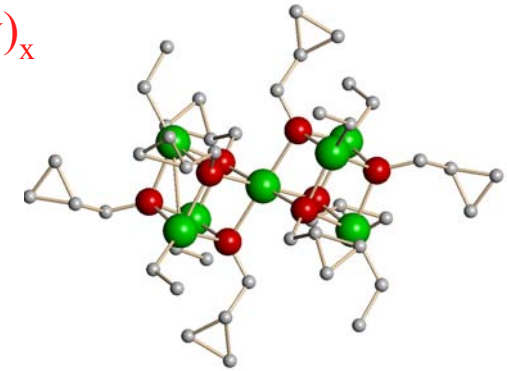
$Zn(DIP)(Et)(py)_2$



$[Zn(ONep)(Et)(py)]_2$

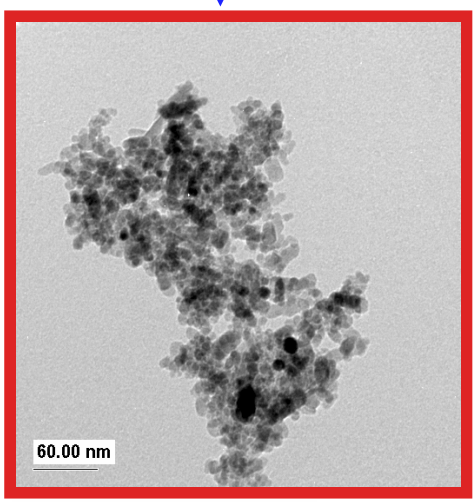


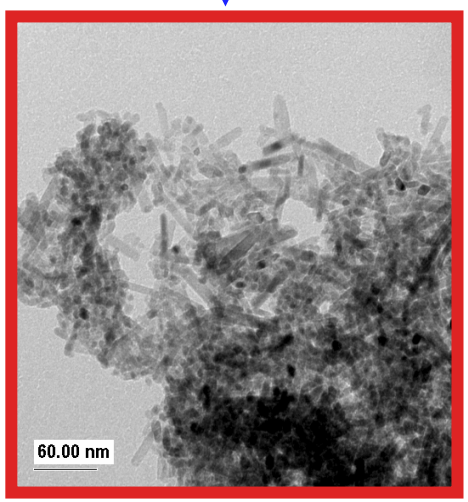
$[Zn(OCPn)(Et)]_4$

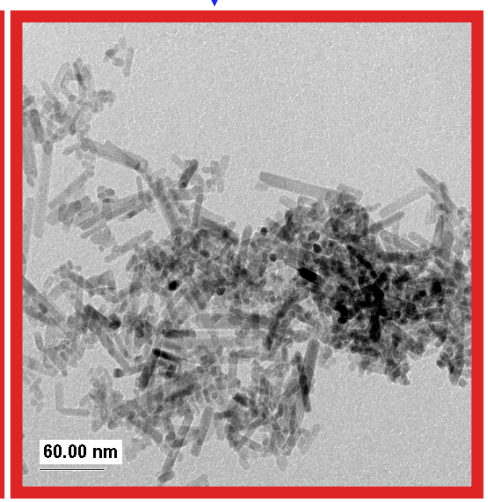


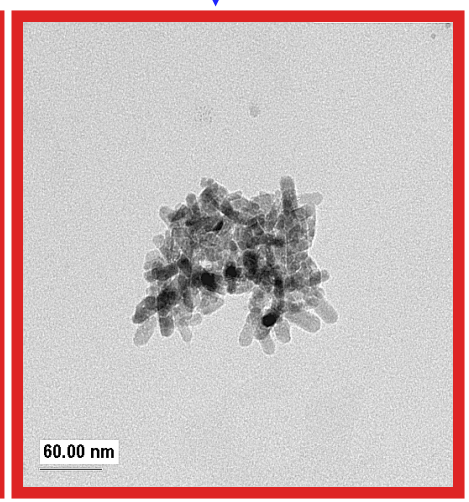
$[Zn(OCPr)(Et)]_7$

MeIm:H_2O 95:5



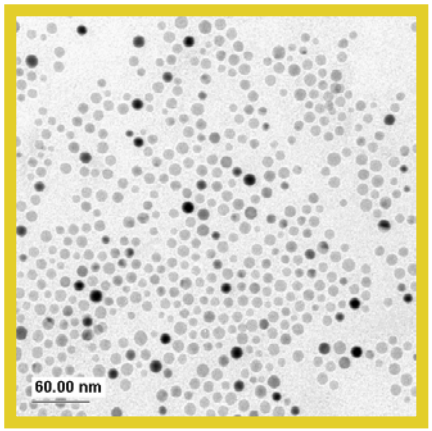




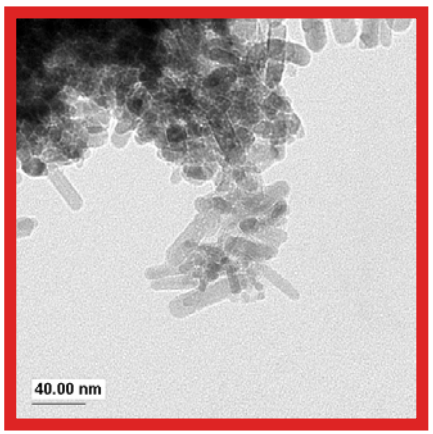


Research team: Tim Boyle, Scott Bunge and Nick Andrews

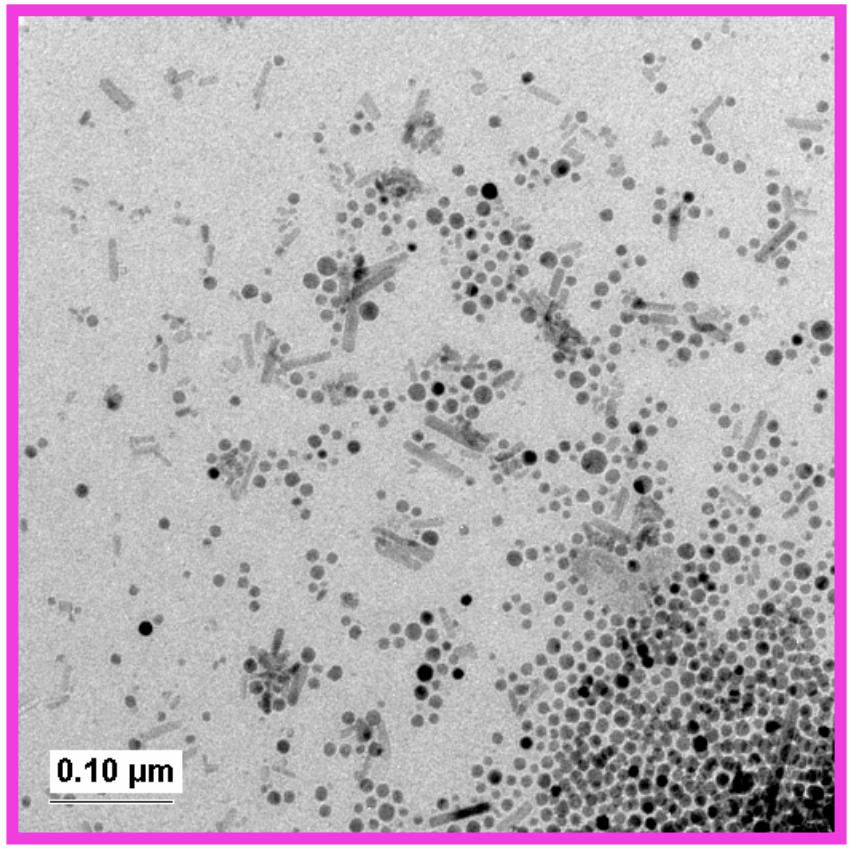
Compatibility of nanoparticle synthesis approaches is being studied



Cu°



ZnO



ZnO/Cu°

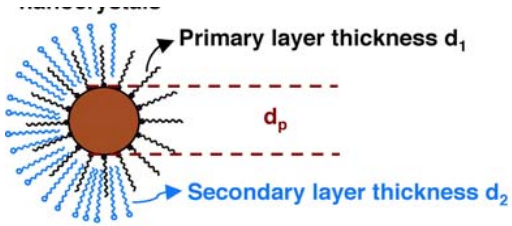
Evaluating integration of nanoparticles into sol-gel films

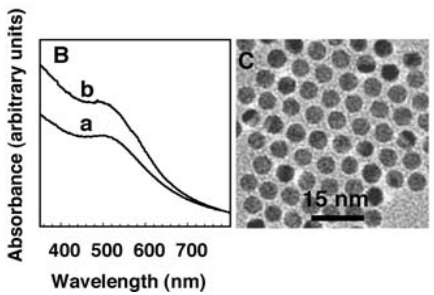
Research team: Tim Boyle, Scott Bunge and Nick Andrews

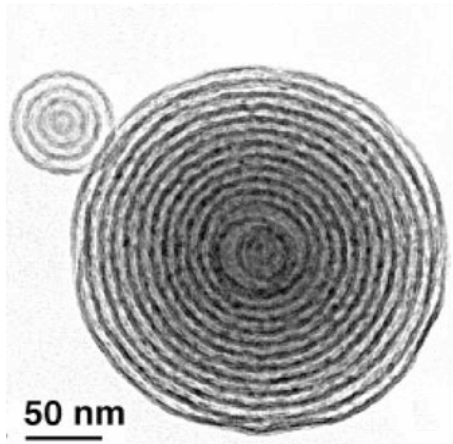
Reliable processing approaches for nanomaterials need to be developed

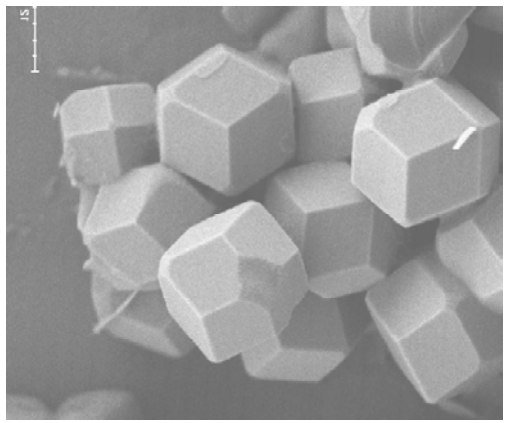
Race to develop new materials/applications - What will be the bottom line in a few years?

- **Can the processes be scaled? How much we can make, at what price?**
- **How reliable are the processes and the products?**
- **How tightly can we control the quality, including compositions, morphologies, sizes, uniformity, etc.**
- **Can the materials meet the functional demand, and how reliable is the functionality?**









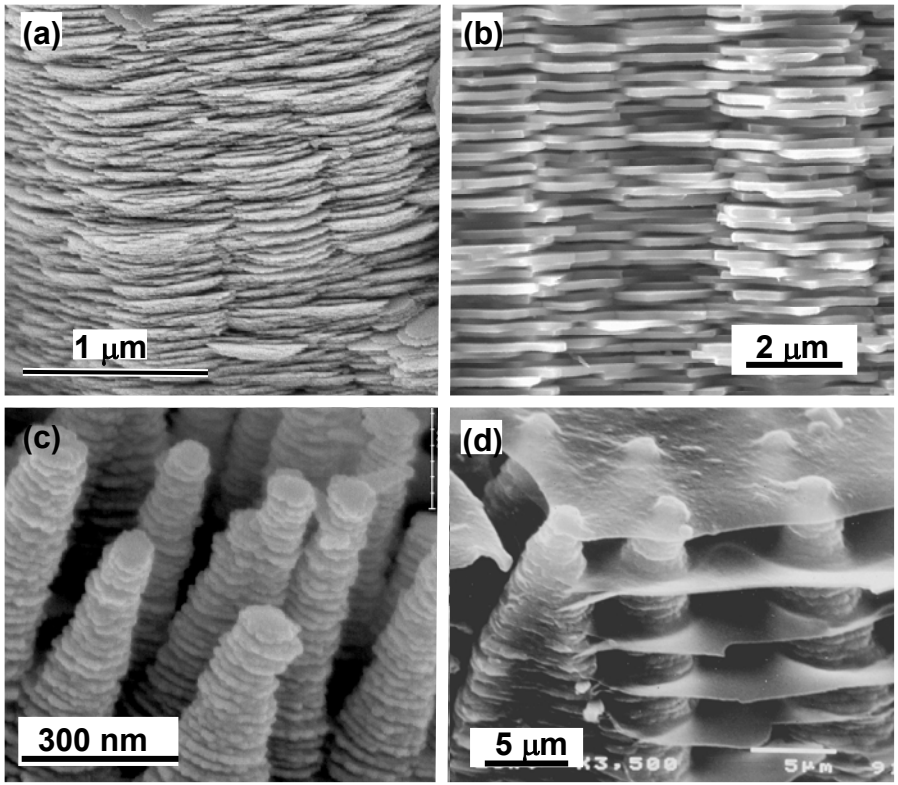
Challenge: Science-based, predictive, robust, scalable processing of nanomaterials

Research Team: J. Liu, J. Voigt, T. Boyle, J. Brinker

Los Alamos

Sandia National Laboratories

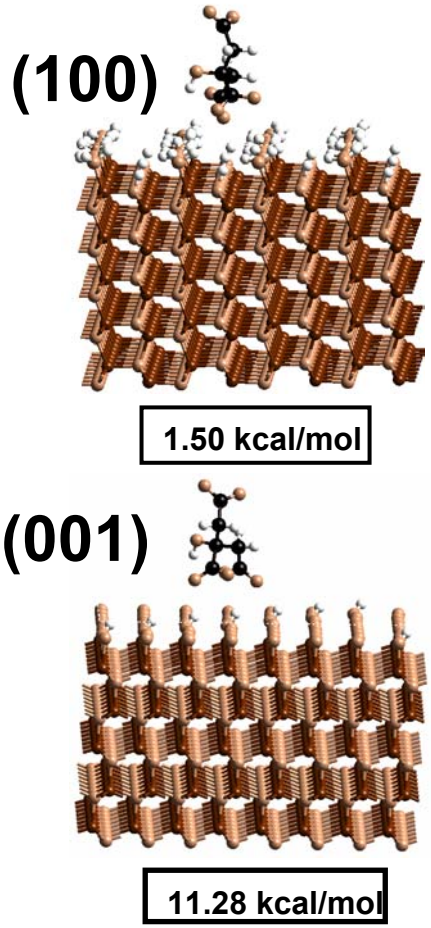
Surface chemistry controls the nucleation & growth of nanostructures and hybrids



ZnO

Abalone shell

Biomimetic ZnO nanostructures



Computer modeling

Research Team: Jun Liu & Jim Voigt

Los Alamos

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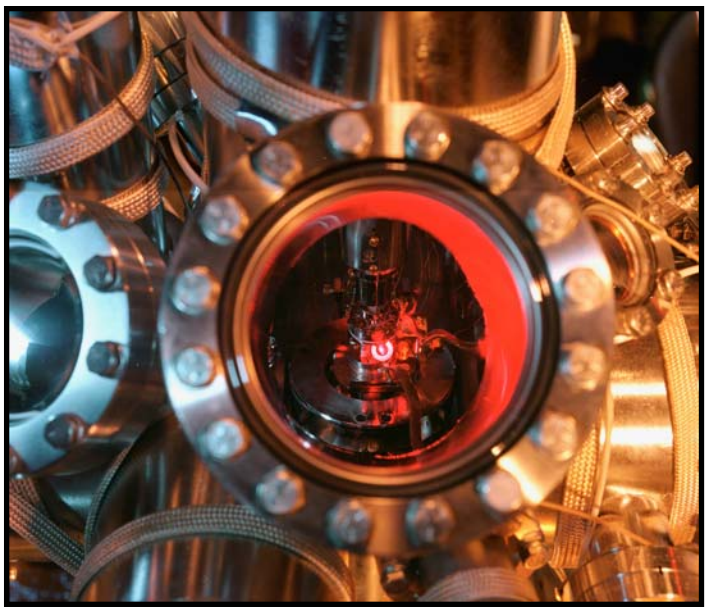
Complex Functional Nanomaterials – Advanced Characterization Methods

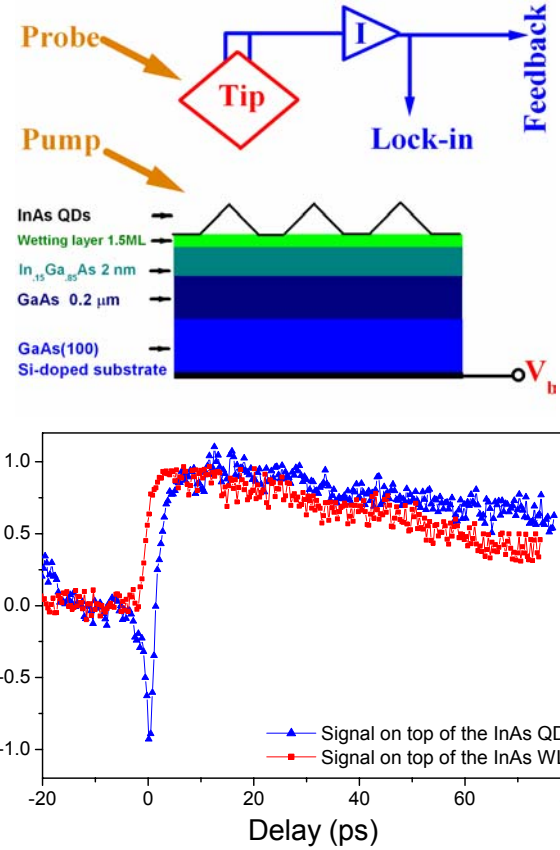
Ultrafast STM

Spatial and temporal atomic-scale imaging of real space processes and excitations with 20 nm / 2 ps resolution



Research Team: T. Taylor et. al.b

Relaxation dynamics in InAs/GaAs SAQDs



Ultrafast STM signal from InGaAs SAQD: permits investigation of single quantum dot photoconductivity

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